



## **Hierarchical Structure and Strengthening Mechanisms in Pearlitic Steel Wire**

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*Publication date:*  
2017

*Document Version*  
Peer reviewed version

[Link back to DTU Orbit](#)

*Citation (APA):*

Zhang, X., Hansen, N., Huang, X., & Godfrey, A. W. (2017). *Hierarchical Structure and Strengthening Mechanisms in Pearlitic Steel Wire*. Abstract from TMS 2017: 146th Annual Meeting and Exhibition, San Diego, California, United States.

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# Hierarchical structure and strengthening mechanisms in pearlitic steel wire

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Microstructure evolution and strengthening mechanisms have been analyzed in a cold-drawn pearlitic steel wire (the strongest engineering materials in the world) with a nanostructure down to 10 nm and a flow stress up to 5.4 GPa. The interlamellar spacing and the cementite lamellae thickness are reduced during drawing in accordance with the change in wire diameter up to a strain of 2.5. At a higher strain enhanced thinning of cementite lamellae points to decomposition and carbon enrichment of the ferrite lamellae. Dislocations are stored as individual dislocations and in low angle boundaries. No saturation in the dislocation density is observed and it increases to  $5 \times 10^{16} \text{ m}^{-2}$  at a strain of 5.4. A high dislocation density at the ferrite/cementite(ferrite) interface is also observed. Boundary strengthening, dislocation strengthening and solid solution hardening are suggested and good agreement is found between the calculated flow stresses and experimental values.

## References:

1. X. Zhang, A. Godfrey, X. Huang, N. Hansen and Q. Liu: 'Microstructure and strengthening mechanisms in cold-drawn pearlitic steel wire', *Acta Mater.*, 2011, 59, 3422-3430.
2. X. Zhang, N. Hansen, A. Godfrey and X. Huang: 'Dislocation-based plasticity and strengthening mechanisms in sub-20 nm lamellar structures in pearlitic steel wire', *Acta mater.*, 2016, 114, 176-183.
3. X. Zhang, A. Godfrey, N. Hansen and X. Huang: 'Hierarchical structures in cold-drawn pearlitic steel wire', *Acta Mater.*, 2013, 61, 4898-4909.
4. X. Zhang: 'Quantitative investigation of microstructural evolution during the cold wire-drawing of a pearlitic steel wire and its relationship with mechanical properties', Phd thesis, 2009, Tsinghua Univ., Beijing.
5. X.D. Zhang, A. Godfrey, X. Huang, N. Hansen, W. Liu and Q. Liu: 'Characterization of the microstructure in drawn pearlitic steel wires', in: *Proceedings of the 30th Risø International Symposium on Materials Science: Nanostructured Metals: Fundamentals to Applications*. Risø, Denmark: DTU, 2009, pp. 409-416.
6. X. Zhang, A. Godfrey, N. Hansen, X. Huang, W. Liu and Q. Liu: 'Evolution of cementite morphology in pearlitic steel wire during wet wire drawing' *Mater. Charact.*, 2010, 61, 65-72.
7. X.D. Zhang, A. Godfrey, W. Liu and Q. Liu: 'Study on dislocation slips in ferrite and deformation of cementite in cold drawn pearlitic steel wires from medium to high strain', *Materials Science and Technology*, 2011, 27, 562-567.
8. X. Zhang, N. Hansen, A. Godfrey, X. Huang, Microstructural evolution, strengthening mechanisms and strength structure relationship in cold-drawn pearlitic steel wire, in: *Proceedings of the 33rd Risø International Symposium on Materials Science: Nanometals: Status and Perspectives*. Risø, Denmark: DTU, 2012, pp. 407-416.
9. X. Zhang, N. Hansen, A. Godfrey and X. Huang: 'Hierarchical structures and strength in cold-drawn pearlitic steel wire', in: *Proceedings of the 35th Risø International Symposium on Materials Science: New Frontiers of Nanometals*. Risø, Denmark: DTU, 2014, pp. 153-170.
10. X. Zhang, A. Godfrey, W. Liu and Q. Liu: 'Evolutions of microstructure and ferritic micro-orientation and texture in a pearlitic steel wire during cold drawing', *Acta Metall. Sin.*, 2010, 46, 141-146.